IS 7358 (1984): Thermocouples [ETD 18: Industrial Process Measurement and Control]

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Indian Standard

SPECIFICATION FOR THERMOCOUPLES

(First Revision)

UDC 621·362·1 : 536·532

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 6

June 1985

Indian Standard

SPECIFICATION FOR THERMOCOUPLES

(First Revision)

Industrial Process Measurement and Control Sectional Committee, ETDC 67

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Indian Standard

SPECIFICATION FOR THERMOCOUPLES

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 3 August 1984, after the draft finalized by the Industrial Process Measurement and Control Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This Indian Standard was first published in 1974, and is revised to incorporate amendments and modifications in test methods.

0.3 The thermocouples covered in this standard are suitable for use in normal pressure.

NOTE — The requirements for thermocouples for use at high pressures are under consideration.

0.4 The reference tables giving the emf-temperature relationship for different thermocouple materials are given in the following Indian Standards:

IS : 2054-1962	Reference tables for nickel/chromium-nickel/aluminium thermocouples
IS : 2055-1962	Reference tables for platinum/rhodium-platinum thermocouples
IS : 2056-1962	Reference tables for copper-constantan thermocouples
IS : 2057-1962	Reference tables for iron-constantan thermocouples
IS : 6720-1972	Reference tables for platinum/30 percent rhodium-platinum/6 percent rhodium thermocouples
IS : 7988-1976	Reference tables chromel-copel thermocouples
IS : 10626-1983	Reference tables for nickel/chromium-copper/nickel (chromel-constantan) thermocouples

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers the requirements and tests for thermocouples.

1.2 This standard does not cover the requirement of mineral insulated thermocouples.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions, in addition to those given in IS : 1885 (Part 11)-1966†, shall apply.

2.1 Termocouple — A pair of conductors of dissimilar materials, joined at one end and intended to form part of an arrangement using the thermoelectric effect for temperature measurement.

NOTE — The thermocouple usually includes associated parts, such as connection head and protecting sheath.

2.2 Thermo-emf — The electromotive force due to a thermoelectric effect.

2.3 Thermoelement — A thermocouple designed for use as a part of thermocouple assembly, without protecting sheath and other associated parts, such as terminal block and connection head.

2.4 Thermal Lag (Thermal Inertia) — The time which elapses from the moment of entry of a thermocouple into a medium having constant temperature to the moment the temperature difference between the medium and hot junction of the thermocouple within the medium is 0·37 times the initial temperature difference between the medium and the thermocouple.

2.4.1 *Low Thermal Lag (Thermal Inertia)* — Thermal lag (thermal inertia) up to and including 1 minute.

2.4.2 *High Thermal Lag (Thermal Inertia)* — Thermal lag (thermal inertia) greater than 1 minute.

*Rules for rounding off numerical values (*revised*).

†Electrotechnical vocabulary: Part 11 Electrical measurement.

2.5 Measuring Junction — That junction of the thermocouple which is subjected to the temperature to be measured.

2.6 Reference Junction — That junction of a thermocouple which is either subjected to a known (reference) temperature or is so located and/or suitably compensated with respect to the measuring equipment that changes in the ambient temperature do not materially affect the measurement of temperature by the measuring junction.

2.7 Continuous Maximum Temperature — The temperature which is experienced by the thermoelement for a period ranging from 100 hours to 1 000 hours during which the change in the thermo-emf does not exceed 1 percent.

2.8 Spot Reading Maximum Temperature — The temperature which is experienced by the thermoelement for a period up to 100 hours during which a change in the thermo-emf does not exceed 1 percent.

2.9 Protective Sheath — A sheath used as a cover to the thermocouple element to protect it from the environment.

2.10 Nominal Length — The distance between the tip of the protecting sheath of the thermocouple up to the head or the place of entry of the leads for thermocouples without head.

2.11 Immersion Length — The distance from the tip of the protecting sheath up to the mating surface of the fixed flange or bottom of the threaded connection.

2.12 Extension Length — The distance from the mating surface of the flange or threaded connection up to the head of the thermocouple.

2.13 Working Length — The length of the thermocouple when measured from the tip of the protecting sheath of the thermocouple, which is supposed to withstand the guaranteed temperature, pressure and influence of the environment.

2.14 Tolerance — Specified maximum deviation in °C from the emf-temperature valves in the reference table, when the reference junction is at 0°C and the measuring junction is at the appropriate temperature.

2.15 Type Tests — Tests carried out to prove conformity with the requirements of this specification. These are intended to prove the general qualities and design of a given type of thermocouple.

2.16 Routine Tests — Tests carried out on each thermocouple to check requirements likely to vary during production.

2.17 Acceptance Tests — Tests carried out on samples taken from a lot for the purpose of acceptance of the lot.

3. THERMOCOUPLE

3.1 The two wires constituting the thermocouple shall be so chosen that any change caused by the physical and chemical conditions to which they are exposed shall not cause any appreciable departure in the calibrated value of emf generated at certain known temperature of the measuring junction and reference junction respectively. The wires constituting the thermocouple shall have physical characteristics suitable for the temperature to which they will be exposed and shall not melt or change in composition by evaporation at these temperatures.

3.1.1 Thermocouples are generally made of the materials specified in **3.1.1.1** and **3.1.1.2**.

3.1.1.1 *Base metals*

a) Copper-constantan,

b) Iron-constantan, and

c) Nickel/chromium-nickel/aluminium.

3.1.1.2 *Noble metals*

a) Platinum/10 percent rhodium-platinum,

b) Platinum/13 percent rhodium-platinum,

c) Platinum/30 percent rhodium-platinum/6 percent rhodium.

3.1.2 When identifying nobel or base metal thermocouples by these nominal alloy combinations, the positive lag shall be listed first.

3.2 Table 1 gives the approximate composition and approximate maximum temperature of the thermocouple materials normally in use.

3.3 Measuring junction of any thermocouple is formed by twisting together the wires and then by joining the tips. As far as possible, oxidation of the metals should be avoided.

3.4 The two wires of the thermocouple should be insulated from each other by a material which shall withstand the highest temperature to which the thermocouple is to be exposed. Usually ceramic material is used for this purpose.

3.5 Thermocouples shall not be used continuously for temperature higher than the maximum continuous temperatures given in Table 1.

TABLE 1 APPROXIMATE COMPOSITION AND APPROXIMATE MAXIMUM TEMPERATURE OF THERMOCOUPLES

(*Clause* 3.2)

THERMOCOUPLE MATERIAL	DESIGNATION	LETTER DESIGNATION	NOMINAL COMPOSITION	PREFERRED WIRE DIAMETER	RECOMMENDED TEMPERATURE		RELEVANT IS REF TABLES
					Continuous Maximum Temperature Range	Spot Reading Temperature, *Max*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Base Metals				mm	°C	°C	
Copper-Constantan	Cu-Con	T	Cu-Cu/Ni (40/45% Ni)	0·5 1·0 1·38 2·5 3·0	−168·9 to + 400	500	IS : 2056-1962*
Iron-Constantan	Fe-Con	J	Fe-Cu/Ni (40/45% Ni)	1·0 1·38 2·5 3·0	0 to 600 0 to 700 0 to 800	1 100	IS : 2057-1962†
Nickel/Chromium-Nickel/Aluminium	Ni/Cr-Ni/Al	K	Ni 90%, Cr 10%-Ni 95% Balance Al, Si, Mn	1·0 1·38 2·5 3·0	−158 to + 900 −158 to + 1 000 −158 to + 1 100	1 300	IS : 2054-1962‡
Noble Metals							
Platinum/10% Rhodium-Platinum	Pt/Rh 10-Pt	S	Pt 90% Rh 10% —Pt 100%	0·35	0 to 1 400	1 650	IS : 2055-1962§
Platinum/13% Rhodium-Platinum	Pt/Rh 13-Pt	R	Pt 87% Rh 13-% —Pt 100%	0·5			IS : 2055-1962§

(*Continued*)

TABLE 1 APPROXIMATE COMPOSITION AND APPROXIMATE MAXIMUM TEMPERATURE OF THERMOCOUPLES — *Contd*

Thermocouple Material	Designation	Letter Designation	Nominal Composition	Prefered Wire Diameter	Recommended Temperature		Relevant IS Ref Tables
					Continuous Maximum Temperature Range	Spot Reading Temperature, *Max*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Noble Metals — Contd							
			percent	mm	°C	°C	
Platinum/30% Rhodium-Platinum/ 6% Rhodium	Pt/Rh 30- Pt/Rh 6	B	Pt 70 % Rh 30—% Pt 94 % Rh 6 %	0·35 0·5	300 to 1 500	1 700	IS : 6720-1972‖

*Reference tables for copper-constantan thermocouples.

†Reference tables for iron-constantan thermocouples.

‡Reference tables for nickel/chromium-nickel/aluminium thermocouples.

§Reference tables for platinum/rhodium-platinum thermocouples.

‖Reference tables for platinum/30 percent rhodium-platinum/6 percent rhodium thermocouples.

Nickel chromium = chromel

Nickel aluminium = alumel.

3.6 The free ends of the thermoelements shall be suitably shaped and marked, if necessary, to facilitate their connection with connectors in the head which is attached to the protecting sheath.

4. PROTECTING SHEATH

4.1 Thermocouples shall be entirely covered by a sheath which shall stand the highest temperature as well as atmosphere to which the thermocouple is to be subjected.

4.1.1 The protecting sheath shall be securely attached to the head of the thermocouple which contains the connectors for attaching the leads and the thermocouple ends.

4.1.2 The details of sheaths commonly used are given in Appendix A.

5. GENERAL REQUIREMENTS AND DIMENSIONS OF THERMOCOUPLES AND COMPONENTS PARTS

5.1 The general requirements and dimensions of the thermocouples and their component parts for which interchangeability is important are given in Appendix B.

6. ACCURACY

6.1 The calibration of individual thermocouple shall agree with the relevant Indian Standards (*see* Table 1) for the particular type of thermocouple within the tolerances specified in Table 2.

7. INSULATION RESISTANCE

7.1 Application Where There is a Possibility of Protecting Sheath Coming in Direct Contact with Electrical Potential — These thermocouples shall have thermoelements insulated from the protecting sheath. The insulation resistance between the thermoelement and the protecting sheath for a nominal length of 1 metre shall be as specified below:

Type of Thermocouple	*Insulation Resistance, Min*
a) All thermocouples	5 MΩ at 27 ± 2°C and relative humidity 45 to 75 percent
b) Thermocouples with upper limit of continuous temperature as 600°C	70 kΩ

c) Thermocouples with upper limit of continuous temperature as 800°C — 25 kΩ

d) Thermocouples with upper limit of continuous temperature as 1 000°C and above — 5 kΩ

TABLE 2 THERMOCOUPLE TOLERANCES

(*Clause* 6.1)

Type of Thermocouple	Tolerance	Temperature Range
(1)	(2)	(3)
Base Metals:		°C
Copper-Constantan*	± 3°C	0 to 300
	± 0·75%	Above 300
Iron-Constantan*	± 3°C	0 to 400
	± 0·75%	Above 400
Nickel/Chromium-Nickel/Aluminium*	± 3°C	0 to 400
	± 0·75%	Above 400
Rare Metals:		
Platinum/Rhodium-Platinum group	± 3°C	0 to 600
	± 0·5%	Above 600
Platinum/Rhodium-Platinum/Rhodium group	± 3°C	0 to 600
	± 0·5%	Above 600

*It should be noted that these thermocouples may be used at a temperature below 0°C, but in these cases the tolerances are usually the subject of agreement between the manufacturer and the user. Where the thermocouple is to be used below 0°C, a calibration on the boiling point of oxygen should be made.

7.2 Application Where There is no Possibility of Protecting Sheath Coming in Direct Contact with the Electrical Quantity — In these types of thermocouples, the thermoelement measuring junction may be separated by air from, or welded to the protecting sheath and the insulation resistance requirements do not apply.

8. MARKING

8.1 The following particulars shall be prominently marked (preferably by way of punching) on the outer surface of the terminal head:

a) Manufacturer's name or trade-mark, if any;

b) Type of thermocouple (for example, Cu-Con);

c) Nominal length;

d) Working length, if different from nominal length;

e) Continuous maximum temperature range; and

f) Country of manufacture.

8.1.1 The thermocouple may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

9. TESTS

9.1 General

9.1.1 *Type Tests* — The following shall constitute the type tests:

a) Accuracy test (**9.2**),

b) Insulations resistance test (**9.3**), and

c) Thermal lag (thermal inertia) measurement (**9.4**).

9.1.2 *Routine Tests* — The following shall constitute the routine tests:

a) Accuracy test (**9.2**); and

b) Insulations resistance test at a temperature of 27 $\pm$ 2°C and relative humidity of 45 to 75 percent (**9.3**).

9.2 Accuracy Tests

9.2.1 Thermocouple shall be tested for millivolts output with the reference junction maintained at 0°C. Otherwise necessary corrections shall be applied if the reference junction is kept at room temperature.

9.2.2 For commercial estimation, it shall be sufficient to compare the millivolt output of the thermocouple inserted in a block of copper to a depth of approximately 10 times the diameter of the thermocouple and heating the block in a tube or muffle furnace of suitable size. A suitable furnace and the temperature equalizing block are described in Appendix B.

9.2.3 The millivolt output shall be measured by a potentiometer standardized on a standard cell or a high sensitivity deflection galvanometer calibrated to read millivolts. Alternatively, a digital voltmeter may also be used to measure millivolt output.

9.2.4 Rare metal thermocouple should preferably be used to check the thermocouple under test. The rare metal thermocouple shall be protected from the reducing atmosphere. It is, therefore, advisable to use a netural or slightly oxidizing atmosphere.

9.2.5 The defining fixed points on the International Practical Temperature Scale 1968*, given in Appendix C may also be used for this test.

9.3 Insulations Resistance Test — The insulation resistance shall be measured with a dc voltage of 500 ± 50V applied for a minimum period of one minute or sufficient time for the pointer of testing instrument to have come practically to rest.

NOTE — For type test, the requirements of **7.1**(a) and the relevant requirements of (b), (c) or (d) shall apply. For routine test, the requirements of only **7.1**(a) shall apply.

9.4 Measurement of Thermal Lag (Thermal Inertia) — The thermocouple under test is connected to a potentiometric type temperature indicator. The temperature indicator should be of fast response type with signalling contacts at two positions.

9.4.1 Two water baths are taken with a suitable arrangement to maintain the temperature constant throughout their mass. These water baths are kept at two different temperatures, the difference being normally kept at about 50°C. The temperature of the two baths is measured accurately by two independent devices. The bath with lower temperature should be either at room temperature or higher than room temperature.

9.4.2 One signalling contact is set corresponding to the temperature of one bath and the second correspondiug to the temperature of the other bath. Contacts of two relays/switches, one with normally open and the other with normally closed contacts are connected in series to each other and in series with an accurate electric stop-watch.

9.4.3 The singalling contact corresponding to the lower temperature is connected to the relay/switch with normally open contacts so that when the pointer of the indicator reaches this temperature the relay operates, open contact of the relay closes and the stop-watch starts.

*Amended edition 1975.

When the pointer of the indicator reaches the position of signalling contact corresponding to 63·2 percent of the difference of temperature between the first bath and the second bath, the second relay operates and the normally closed contact opens, the stop-watch stops.

9.4.4 The thermocouple connected to the indicator is kept in the bath at the lower temperature. As soon as the pointer of the indicator reaches just near to the signalling contact corresponding to lower temperature. The thermocouple under test is transferred from the bath at lower temperature to the bath at higher temperature without any loss of time. Immediately after this transfer, the lower temperature signalling contact would operate and stop-watch starts. When the indicator pointer reaches the second signalling contact, the stop-watch stops. The time elapsed, indicated by the stop-watch, is directly the thermal lag.

APPENDIX A

(*Clause* 4.1.2)

PROTECTING SHEATHS

A-1. METALLIC SHEATHS

A-1.1 The details of metallic sheaths are given in Table 3.

A-2. REFRACTORY SHEATHS

A-2.1 The details of refractory sheaths are given in Table 4.

APPENDIX B

(*Clause* 5.1)

GENERAL REQUIREMENTS AND DIMENSIONS OF THERMOCOUPLES AND COMPONENT PARTS

B-1. GENERAL REQUIREMENTS

B-1.1 Terminal Head

B-1.1.1 The terminal head shall contain a terminal block of ceramic insulating material with terminals for the thermocouple and the extension leads.

TABLE 3 METALLIC SHEATHS

(*Clause* A-1.1)

SL No.	GENERAL DESCRIPTION	MAXIMUM TEMP °C	PROTECTION AFFORDED AGAINST	USUAL CAUSE OF FAILURE	REMARKS
(1)	(2)	(3)	(4)	(5)	(6)
i)	Mild steel, solid-drawn or welded	800	Oxidation, but emits metal vapour above 500°C	Oxidation and/or fluxing in metals	Welded end, or bored from soild
ii)	Mild steel, solid-drawn surface treated by 'calorizing'	900	Oxidation but emits metal vapour above 500°C	Oxidation and/or fluxing in metals less rapid than mild steel, solid-drawn or welded	Welded end, before surface treatment
iii)	Nickel-free stainless iron	800	Low temperature molten metals, but emits metal vapour avove 500°C	Oxidation	Bored from solid
iv)	High chromium nickel stainless steels	1 000	Oxidation, but emits metal vapour above 500°C	Oxidation and/or fluxing in metals less rapid than nickel-free stainless iron	Welded end
v)	Nickel-chromium alloy with some iron, solid-drawn	1 000	Oxidation, but emits metal vapour above 500°C may also re-emit absorbed SO_2 or CO	Oxidation, slow and attack by SO_2 or CO, fluxing in metals	Welded end
vi)	Nickel-chromium alloy with some iron cast*	1 000	Oxidation, but emits metal vapour above 500°C may also re-emit absorbed SO_2 or CO	Oxidation, slow and attack by SO_2 and CO fluxing in metals	Cast with closed end, bore shall be freed from core-wires
vii)	Nickel-chromium alloy nominally pure cast*	1 000	Oxidation, but emits metal vapour above 500°C, may also re-emit SO_2 or CO	Oxidation, slower than as in (vi), and attack by SO_2 or CO, fluxing in metals	Cast with closed end, bore shall be freed from core-wires
viii)	Nickel-chromium alloy with 1 to 2 percent tungsten	1 100 (in most cases)	Generally similar to nickel-chromium alloy, but more* resistant to corrosion attack		

*There is evidence that the addition of a little tungsten is advantageous.

TABLE 4 REFRACTORY SHEATHS

(*Clause* A-2.1)

SL No.	GENERAL DESCRIPTION	MAX TEMP	PROTECTION AFFORDED AGAINST	USUAL CAUSE OF FAILURE	REMARKS
(1)	(2)	(3)	(4)	(5)	(6)
i)	Fused silica, milky	1 100	Oxidation, gas entry, but may emit silicon above 800°C	Devitrification, fluxing in slag, etc	End closed by fusing, withstands temperature shock
ii)	Fused silica, clear	1 100	Oxidation, gas entry, but may emit silicon above 800°C	Devitrification, fluxing in slag etc	End closed by fusing, withstands temperature shock
iii)	Fire-clay	1 400	Oxidation	Cracking, fluxing or building up	Usually open ended outer sheath
iv)	Porcelain, glazed and unglazed	1 400	Oxidation, gas entry	Cracking, fluxing or building up	Closed and moulded before firing, manufacturer's recommendations should be followed in the use of porcelain
v)	Re-crystallized alumina	1 700	Oxidation, gas entry	Cracking, fluxing or building up, slow. Failure usually traceable to 'binder'	—
vi)	Silicon carbide	2 000	Oxidation to 1 400°C	Fluxing or disintentation of 'binder'	Not much used except as outer sheath
vii)	Alundum	1 500	Oxidation	Cracking, fluxing or building up	—

B-1.1.2 The extension leads shall be taken through cable gland fitted to the terminal head.

B-1.2 Protecting Sheath — Outer protecting sheath closed at one end (gastight) which shall be made, according to purpose, either of metal or ceramic, shall normally be used.

B-1.2.1 The outer metallic protecting sheath shall be drawn seamless or gastight resistance welded.

B-1.2.2 For rare metal thermocouples and for those thermocouples the outer protecting sheaths of which are not gastight, an additional gastight inner ceramic protecting sheath which shall fit closely inside the outer protecting sheath should preferably be provided.

NOTE 1 — Inner ceramic protecting sheath may also be provided for the base metal thermocouples, if required by the purchaser.

NOTE 2 — In cases where rapid response is necessary, the inner ceramic protecting sheath need not be used.

B-1.3 Holding Tube

B-1.3.1 Holding tubes are employed to secure and protect the ceramic protecting sheaths and to mount the terminal head.

B-1.3.2 *Holding tubes are made of mild steel*

B-1.4 Thermoelement

B-1.4.1 Suitable identification shall be provided on the terminal block to distinguish the polarity of the thermoelement.

B-1.4.2 If in a thermo-element, only one wire is covered with insulating tube, then this wire shall be the positive wire.

B-2. STRAIGHT TYPE THERMOCOUPLES

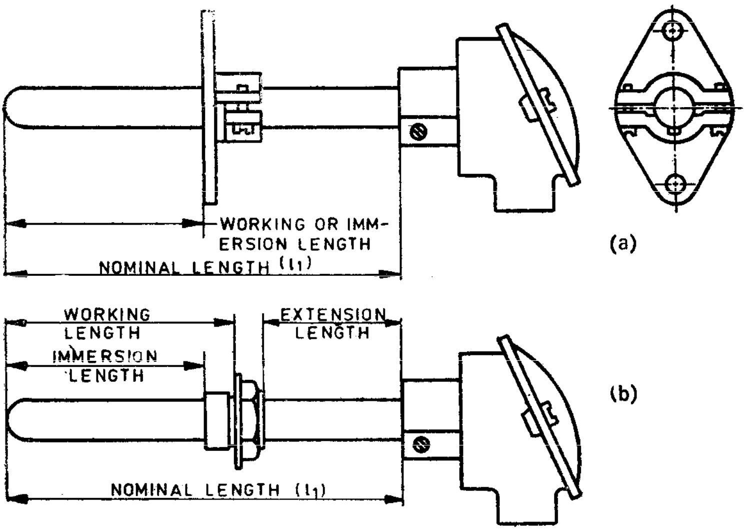
B-2.1 Nominal Length — The nominal length of the thermocouple (*see* Fig. 1) shall be chosen from 180, 250, 355, 500, 710, 1 000, 1 400, 2 000 and 3 000 mm.

B-2.2 Protecting Sheaths — The dimensions, length, diameter and wall thickness of protecting sheaths (*see* Fig. 2) shall be as given in Table 5.

B-2.3 Holding Tubes for Ceramic Protecting Sheaths

B-2.3.1 *Radial Clearance* — The radial clearance between the outer diameter of the outermost protecting sheath and the inner diameter of the holding tube shall be from 2 to 2·5 mm.

B-2.3.2 *Holding Tube Length Projecting Out of Terminal Head* — The length of the holding tube projecting out of the terminal head shall be chosen from 80, 150, 200 and 300 mm.



(a) Thermocouple with Adjustable Flange Mounting
(b) Thermocouple with Screw Flange Mounting

FIG. 1 STRAIGHT TYPE THERMOCOUPLE

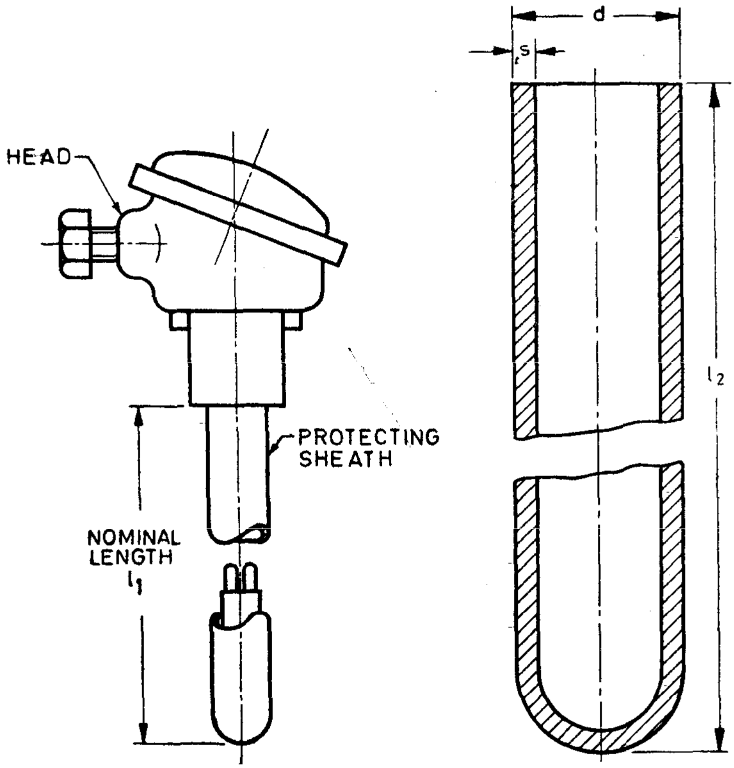


FIG. 2 PROTECTING SHEATH

TABLE 5 DIMENSIONS OF PROTECTING SHEATHS

(*Clause* B-2.2)

MATERIAL	DIMENSION		
	d	s	l_2
	mm	mm	mm
Metallic	15	2	195, 265, 370, 520, 730, 1 020, 1 420, 2 020 and 3 020
	21	2·5	
	22	2	
	24	3	
Ceramic	10	1·5	200, 270, 375, 530, 740, 1 030, 1 430 and 2 030
	15	2	
	24	2·5, 3	

NOTE — Any length may be chosen for a protecting sheath of a given diameter and wall thickness.

B-2.4 Distance of Measuring Junction from the Projecting Sheath — The distance between the measuring junction of the thermo-element and inner side of the innermost projecting sheath shall not exceed 5 mm.

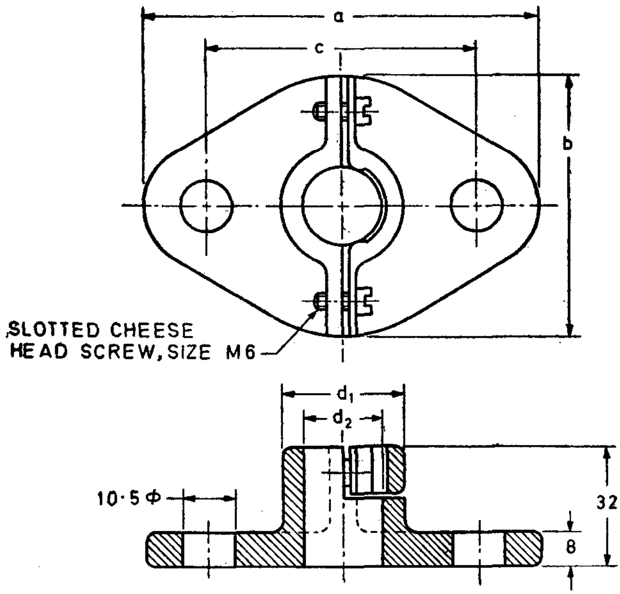
NOTE — The above requirement also applies to angle type thermocouples.

B-2.5 Fixing Flange — The fixing flange, when provided, shall be in accordance with Table 6.

TABLE 6 DIMENSIONS OF FIXING FLANGES

(*Clause* B-2.5)

All dimensions in millimetres.



FIXING FLANGE

<table>
<tr><th>NOMINAL SIZE</th><th>a</th><th>b</th><th>c</th><th>d_1</th><th>d_2</th></tr>
<tr><td>15</td><td>75</td><td>50</td><td>55</td><td>26</td><td>16</td></tr>
<tr><td>21</td><td rowspan="4">90</td><td rowspan="4">65</td><td rowspan="4">70</td><td>32</td><td>22</td></tr>
<tr><td>22</td><td>33</td><td>23</td></tr>
<tr><td>24</td><td>35</td><td>25</td></tr>
</table>

B-3. ANGLE TYPE THERMOCOUPLES

B-3.1 The dimensions of the protecting sheaths, supporting tubes and the supporting sleeves shall be in accordance with Table 7.

APPENDIX C

(*Clause* 9.2.5)

FURNACE AND TEMPERATURE EQUALIZING BLOCK

C-1. DESCRIPTION

C-1.1 A vertical furnace of 100 mm in diameter and 1 000 mm in length and having a rating of 5 kW should be used. It should be provided with automatic temperature control to maintain the temperature at any desirable point within the temperature range of thermocouple to be calibrated. The furnace is built with refractory tube wound with heavy gauge wire and set in fosalsil* bricks with outer shell. Closely bunched junctions may be inserted to the same depth and the opening plugged to reduce leakage and internal convection currents. Temperature within $\pm 1°C$ from room temperature to 550°C can be had using a copper equalizing block with 5 holes for receiving the thermocouples. For temperature higher than 550°C equalizing blocks of heat resistance steels shall be used.

C-1.1.1 The block is 500 × 75 mm with 450 mm pedestal and spacers.

APPENDIX D

(*Clause* 9.2.5)

REFERENCE POINTS ON THE INTERNATIONAL PRACTICAL TEMPERATURE SCALE 1968 (AMENDED EDITION 1975)

D-1. REFERENCE POINTS

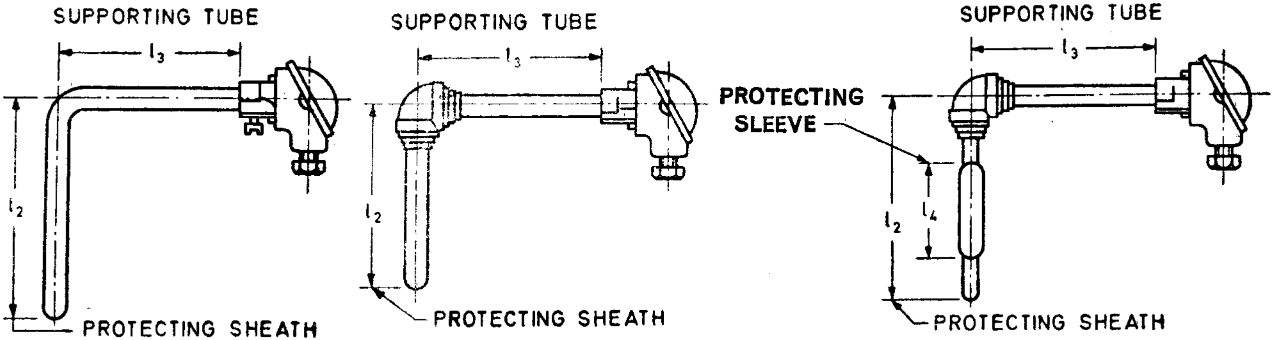
D-1.1 The following points of the International Practical temperature Scale 1968 (amended edition 1975) may serve as reference points. At least two of these points shall be chosen. For sub-zero measurement one of the points shall be sub-zero.

*A heat insulating fire resisting material of great mechanical strength made from moler and used in the form of hollow blocks for partitions.

TABLE 7 DIMENSIONS OF ANGLE TYPE THERMOCOUPLE

(*Clause* B-3.1)

All dimensions in millimetres.



Type 1 **Type 2** **Type 3**

Type of Thermocouple	Length		
	Protecting Sheath (Hot Arm) l_2	Supporting Tube (Cold Arm) l_3	Protecting Sleeve l_4
Type 1	300	330	—
	500	500	—
	1 000	570	—
Type 2	500	330	—
	500	500	—
	710	570	—
Type 3	300	330	150
	500	500	300
	710	570	400

(Standard atmosphere = 1·013 25 Pa)

Defining Fixed Point	*Temperature* (°C)
Condensation point of oxygen	— 182·962
Triple point of water	0·01
Boiling point of water	100
Freezing point of tin	231·968 1
Freezing point of zinc	419·58
Freezing point of silver	961·93
Freezing point of gold	1 064·43

Secondary Reference Point	*Temperature* (°C)
Freezing point of mercury	— 38·836
Ice point	0
Freezing point of lead	321·108
Freezing point of antimony	630·75
Freezing point of copper	1 084·88
Freezing point of nickel	1 455
Freezing point of cobalt	1 495
Freezing point of palladium	1 554
Freezing point of platinum	1 769